Tropical Western Pacific

Site Science Mission Plan

January – June 1999

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Thomas P. Ackerman and James H. Mather
ARM TWP Site Scientist Office
Department of Meteorology
Pennsylvania State University
State College, Pennsylvania 16802

and

William E. Clements and Fairley J. Barnes
ARM TWP Program Office
Atmospheric and Climate Studies Group
Earth and Environmental Sciences Division
Los Alamos National Laboratory
Los Alamos, New Mexico 87544

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PREFACE

The purpose of the TWP Site Scientific Mission Plan is to provide information for the planning of scientific activities in the TWP locale. It will update the status of the locale at 6-month intervals with a detailed projection for the next 6 months as well as longer-term views when appropriate. All acronyms used are defined in the Acronym Section.

These plans are available on the ARM homepage at:
www.arm.gov.

Printed copies can be obtained from either:

ARM TWP Program Office, D407
Los Alamos National Laboratory
P. O. Box 1663
Los Alamos, New Mexico, 87545, USA
Tel: 505-667-1186, Fax: 505-667-9122
twppo@lanl.gov

ARM TWP Site Scientist Office
Department of Meteorology
Pennsylvania State University
503 Walker Building
University Park, PA 16802-5013
Tel: 814-865-2915, Fax: 814-865-3663
ackerman@essc.psu.edu, mather@essc.psu.edu

INTRODUCTION

The Department of Energy's Atmospheric Radiation Measurement (ARM) program was created in 1989 as part of the US Global Change Research Program to improve the treatment of atmospheric radiative and cloud processes in computer models used to predict climate change. The overall goal of the ARM program is to develop and test parameterizations of important atmospheric processes, particularly cloud and radiative processes, for use in atmospheric models. This goal is being achieved through a combination of field measurements and modeling studies. Three primary locales were chosen for extensive field measurement facilities. These are the Southern Great Plains (SGP) of the United States, the Tropical Western Pacific (TWP), and the North Slope of Alaska and Adjacent Arctic Ocean (NSA/AAO), as shown in Figure 1. This Site Science Mission Plan [RPT(TWP)-010.004] describes the ARM program in the Tropical Western Pacific locale.

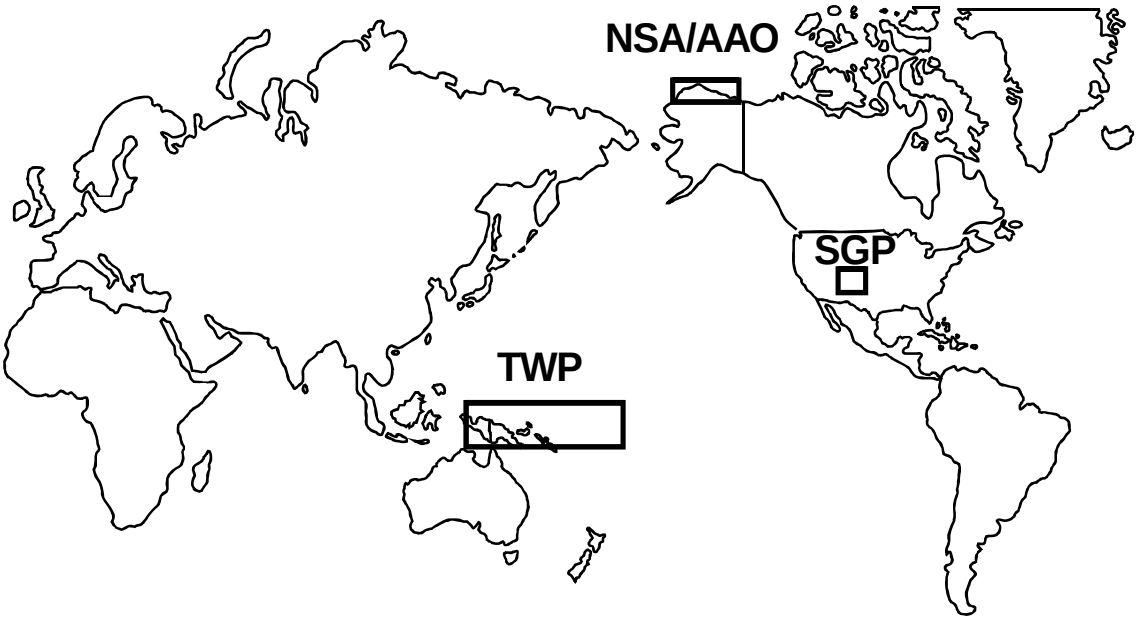


Fig.1. Locations of the three primary ARM locales.

The Tropical Western Pacific locale is the second site to be instrumented by the U.S. Department of Energy's ARM program. The TWP locale, shown in Fig. 2, encompasses the area from 10°N to 10°S of the equator and from Indonesia to east of the international dateline. The locale was selected[1] because of the existence of the Pacific warm pool, the resulting cloud formations, and its influence on weather and climate throughout the planet. The purpose of the TWP program is to collect long-term data to better understand the effect of tropical clouds on the earth's energy budget. The overall

[1] U. S. Department of Energy (DOE), 1991. Identification, Recommendation, and Justification of Potential Locales for ARM Sites. DOE/ER-0495T, National Technical Information Service, Springfield, Virginia.

science objectives and measurement strategy for the TWP are given in ARM Science Plan[2].

Currently TWP program plans to implement three island-based sites (Fig. 2) with Atmospheric Radiation and Cloud Stations (ARCS) by the year 2001. In addition the TWP program is pursuing ways of obtaining data over the open ocean in the locale with instrumented buoys and ship studies. These data along with satellite data will constitute the basic ARM TWP data set. Intensive operational periods (IOP), campaigns, and collaborations with other studies in the locale will occur as the site matures.

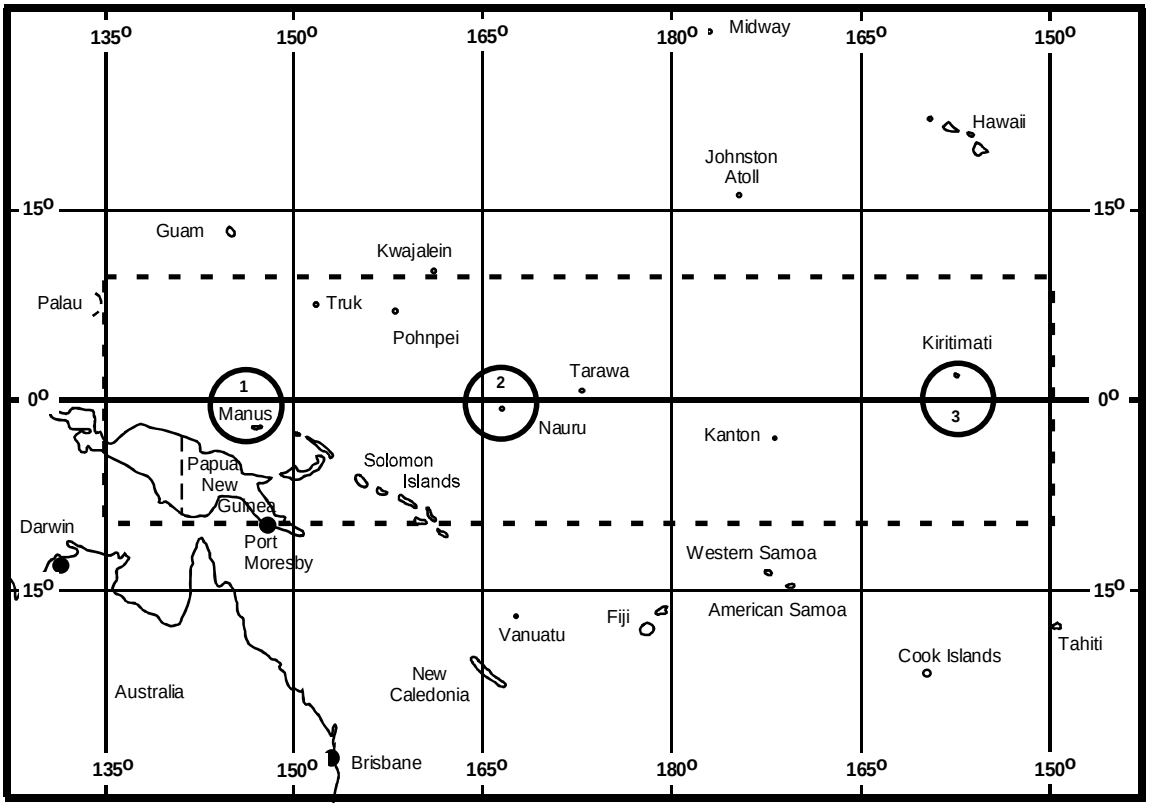


Fig. 2. Equatorial Western Pacific region showing TWP locale (dashed area) and proposed ARCS sites (circles).

[2] U. S. Department of Energy (DOE), 1996. Science Plan for the Atmospheric Radiation Measurement Program (ARM). DOE/ER-670T, National Technical Information Service,

SCIENCE GOALS

The basic science goals of the Tropical Western Pacific component of the ARM program are:

1. Determine the magnitude of the surface radiation budget terms and determine their spatial and temporal variability.
2. Identify bulk and optical properties of clouds in the TWP and how these properties affect the radiation budget.
3. Understand the linkages among sea surface temperature, ocean-atmosphere coupling, surface radiation budget, and tropical convection.
4. Determine vertical transports of water vapor, energy, and momentum in convective cloud systems.

These goals represent a sequence of increasing complexity of knowledge, as well as increasing complexity of measurement. The first is fundamental. We have relatively incomplete knowledge of the surface radiation budget in the TWP, particularly over periods of time longer than a month or a few months. Similarly, high-resolution measurements of bulk cloud properties in the TWP have only been made for short periods of times during campaigns or research vessel cruises. Further, data sets to establish the effect of clouds on the radiation budget do not exist. The third goal seeks to understand the processes in the TWP that connect surface fluxes, sea surface temperature, and convection. These connections are at the heart of meteorology in the TWP and must be well understood for both short-range and long-range climate modeling. The fourth goal represents the linkage between cloud systems and the larger circulation patterns of the region. In addition, it encapsulates cloud feedback processes as they impact the surface radiation budget and sea surface temperature.

The TWP area of interest to ARM is very large, mostly ocean, logistically remote, and operationally costly. Consequently, ARM operations in the TWP will be more limited in scope than in some other locations. Achieving the scientific goals will require a careful blending of long-term, surface remote sensing observations with field campaigns and satellite observations. The Atmospheric Radiation and Cloud Station (ARCS) currently operating at Manus Island, PNG, and on Nauru Island are the first step in the acquisition of long-term data on surface radiation budget and cloud properties. The planned deployment of an additional ARCS on Kiritimati Island will further enhance this acquisition.

The ARM TWP team carefully selected the ARCS instrumentation to address the issues raised by the first two goals. A list of ARCS measurements and instruments is given in Table 1. Detailed information on the various instruments is available on the ARM homepage: www.arm.gov. The system measures all components of the surface radiation budget. The system currently measures only cloud-based heights and cloud base temperature or cloud emissivity, depending on the cloud thickness. The program plans to upgrade the cloud measurements to include cloud top, as well as base height, and cloud fraction. In addition, routine measurements of the atmospheric base state are

acquired with radiosondes, profilers, and surface meteorological sensors. A summary of the data acquired by the Manus ARCS during this current period is given in Section 1.2.1. We encourage members of the scientific community to access that data and use it in their research.

Table 1. ARCS Measurements and Instruments

Measurement	Instruments
Surface radiation	• Up- and down-looking pyranometers and pyrgeometers • Sun-shaded pyranometer and pyrgeometer • Normal incidence pyrheliometer • Up- and down-looking 9-11μm narrow field of view radiometers • UV-B hemispheric radiometer • Broad band (solar and infrared) net radiometer • Atmospheric Emitted Radiance Interferometer (Nauru site only)
Surface meteorology	• Temperature and relative humidity sensor • Barometer • Optical rain gauge • Propeller vane anemometer
Cloud properties	• Cloud lidar (523 nm) • Ceilometer (7.5 km maximum range) • 35 GHz radar [a] • Whole sky imager
Aerosol optical depth	• Multi-filter rotating shadow band radiometer (total, direct, and diffuse irradiance in six 10 nm channels)
Column water	• Dual channel (23.8 and 31.4 GHz) microwave radiometer
Vertical structure of the atmosphere	• Rawinsonde • 915 MHz wind profiler with RASS[b]

a - Currently only at Nauru

b - Operated in cooperation with NOAA's Aeronomy Lab

SITING STRATEGY

An important property of the climate in the tropical Pacific is a strong east to west gradient in various climate parameters including sea surface temperature, water vapor column, and frequency of convection. High sea surface temperatures and frequent, deep convection characterize the western Pacific. Toward the eastern Pacific, there is a steady decline in sea surface temperature and a corresponding decrease in the frequency of convection. Because of this longitudinal structure and its variability it would be difficult to characterize the climate of the tropical Pacific with a single site. The plan for ARM in the TWP is to deploy an ARCS at three sites to sample the structure in this region, as shown in Fig. 2.

The deployment schedule and status of the sites are given in Table 2. The current implementation plan calls for the TWP locale to be fully operational by 2001. ARM and South Pacific Regional Environment Programme (SPREP) are working closely together in siting, public awareness, educational, and other aspects of implementing the TWP locale.

Table 2. TWP ARCS Sites Proposed Schedule and Status

	Site	Latitude	Longitude	Start Date	Status
1	Manus	2.060°S	147.425°E	1996	Operations began in October 1996
2	Nauru	0.522°S	166.912°E	1998	Operations began in November 1998
3	Kiritimati	1.87°N	157.33°W	2000	Planned

1.0 MANUS SITE (ARCS-1), PAPUA NEW GUINEA

The first TWP site is in Manus Province, Papua New Guinea (PNG). This site was chosen because of its location within the heart of the Pacific warm pool, the existence of a NOAA Integrated Sounding System (ISS), and the support of the PNG National Weather Service (NWS). The site is located at the NWS station at the Momote airport on Los Negros Island at 2.060^{o}S, 147.425^{o}E (Fig. 3).

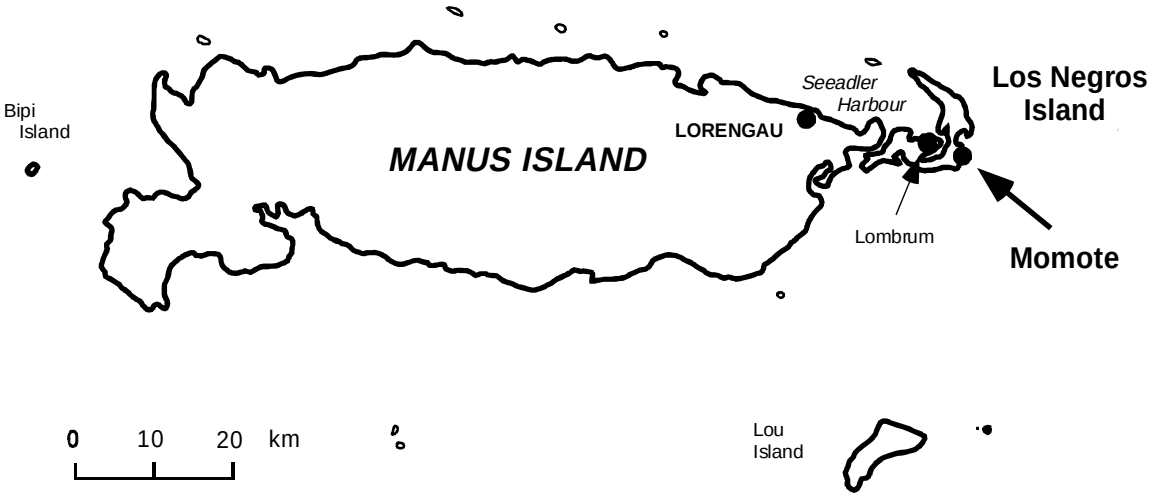


Fig. 3. Manus Province, Papua New Guinea. The ARCS is located at the National Weather Service station at the Momote airport on Los Negros Island.

The site is 6 meters above sea level. The highest point on Manus Island is 702 m, but most of the island has an elevation of less than 200 m. The highest point on Los Negros Island is 121 m but within 3 km of the site the elevation is less than 20 m. All equipment is located within the National Weather Service compound at Momote (Fig. 4). Appendix A shows the Manus site layout of instruments and facilities. The operation of the Momote site is a collaborative effort between ARM TWP and the PNG National Weather Service.

Fig. 4. ARCS installation at National Weather Service station at Momote airport, Manus Province, PNG.

1.1 Manus Operations

ARCS-1 was installed at Momote during August and September 1996. It was shipped from Long Beach, California on 22 May and all components were on site by 07 August. Installation began on 24 August and took 6 weeks and 435 man-days of work for completion. The site was formally commissioned on 12 September and routine operations began on 8 October. PNG NWS staff is in charge of the daily operations of the site. Assistance in performing these duties and in troubleshooting problems is provided by the TWP Operations Center in the US. Phone, fax, and satellite conduct communications between the site and the Operations Center. A REgional SErvice Team (RESET) visits the site periodically to perform maintenance and calibration. These routine visits are nominally scheduled at six-month intervals. Additional visits are made when required.

Operation of the Manus site is managed out of the TWP Operations Center at Los Alamos National Laboratory in collaboration with the Papua New Guinea National Weather Service.

1.1.1 Manus Operations Status

The Manus site has been operating since 8 October 1996. Currently all planned instrumentation except the cloud radar are installed and operating. Helium is being used as the lift gas for the once per day balloon borne sounding at 00Z (1000 Mountain Standard time). Health and status data are transmitted hourly from the site to the ARM Experiment Center via the GOES satellite system. All data are returned on tape monthly by courier service. Locally, three PNG NWS personnel operate the site.

RESET Visits:

A Regional Service Team (RESET) visit consists of two or more TWP technicians and is classified as either a routine or non-routine visit. Routine visits are primarily aimed at instrument calibration, observer training, and semi-annual maintenance. They are scheduled at 6-month intervals. Non-routine visits are for special retrofits or emergency repairs and can be initiated at any time.

During July through December 1998 TWPPO conducted one RESET trip to the Manus site.

RESET-4: (August 1998, 2 weeks, 3 people). This was a non-routine visit for installation of the Whole Sky Imager(WSI). Other tasks were the repair of the UPS system, ADaM repair and maintenance, Brusag solar tracker replacement and another replacement of the MPL diode. The team also spent 2 days troubleshooting the High Resolution Picture Transmission (HRPT) system at the PNG NWS in Port Moresby.

Significant Events

Below are significant operational events that occurred during the July – December 1998 period. The sequential labels (MAS-SE-N) indicate the Manus (MAS) Significant Event (SE) and number (N). A record of all events is available on the TWP website at: www.twppo.lanl.gov.

MAS-SE-13: MPL diode replacement:
The MPL diode was replaced on 15 August 1998 during RESET-4. For more than a month prior the MPL required numerous recycling of power, and condensation inside the glass was a reoccurring problem. The diode was replaced at RESET-Special and RESET-3 also.

MAS-SE-14: I-Van UPS repair:
The Instrument Van UPS electronics module failed on 6 January 1998. The Instrument Van UPS was powered with an extension cord run from the D-Van until a repair could be made. The electronics module was replaced on 15 August 1998 during RESET-4.

MAS-SE-15: WSI Installed:
A WSI and associated computers were installed during the RESET-4 on 14 August 1998.

MAS-SE-16: Solar Tracker arms replaced:
The Skyrad Brusag Solar Tracker was having tracking problems as well as arm seal deterioration. The tracker arms were replaced with parts from the spare on site on 14 August 1998 during RESET-4.

MAS-SE-17: Inmarsat B Transceiver failed:
On 27 August 1998 the Inmarsat B transceiver stopped functioning. It was eventually packed up and sent back to the US for repair and returned to Manus. It then began working on 16 October 1998.

MAS-SE-18: GENSET shutdown:
The emergency backup generator (GENSET) was shutdown on 16 November 1998, because it had a low oil pressure light indicator. Hastings/Deering out of Lae, PNG repaired the generator (no major problems) and it come back on line on 27 November 1998.

1.1.2 Manus Operations Projection

During the January – June 1999 period RESET visits are scheduled as follows:

RESET-5M (cmobined with RESET-5N) This is a routine visit for the following:

- **Calibration:** General instrument change out, calibration and comparison testing.
- **Diesel Generator:** Safety mods to the emergency generator and fuel tank.
- **ADaM/EVE:** Tape drive rotation, sync up ADaM & EVE as well as fail over troubleshooting.
- **Lightning protection:** Install lightning protection rod and grounding for the SMET tower.

RESET-6M Visit

This is a non-routine visit for the following:

- **MMCR:** Install a Millimeter Cloud Radar (MMCR).
- **MPL-HR:** Replace the existing Micro Pulse Lidar with a new high resolution system.
- **Y-Van:** Install and power a new storage van (used for shipping the MMCR).
- **RBL:** Install a Remote Balloon Launcher (RBL) to enable safe launching of balloons.
- **H2 Generator:** Repair the existing NWS Hydrogen Generator and train Observers in its use.

1.2 Manus Data Quality

The TWP Site Science Office at Penn State University reviews all TWP data before being released for use. Data quality is assessed in two stages. First, the site transmits data via GOES satellite each day. This message includes hourly statistics (mean, maximum, minimum, and standard deviation) of most data streams. These data are automatically plotted each day and manually inspected for problems by the site science office. Full examination is reserved for the arrival of the complete tape data set.

Once the full data set is retrieved, the data are plotted using a set of Matlab tools developed at Penn State. These plots include simple daily plots of the raw data and diagnostic plots of instrument to instrument and instrument to model comparisons.

1.2.1 Manus Data Quality Status

We have three specific goals related to the analysis of data quality.

1. Completely describe the existence of the data: Report the periods when the instrument produced data for each instrument. We have organized the information derived from this analysis so that it will be easy to determine what instruments were operating for any given period or, conversely, to determine for which periods a certain set of instruments were operating.

Table 3: Data Gaps during 1998 at the Manus Site

Instrument Platform	Operational Period	Total Days Missing Data
SKYRAD	1 Jan. – 31 Oct.	22.0[a]
GNDRAD	1 Jan. – 31 Oct.	12.2[a]
SMET	1 Jan. – 31 Oct.	15.2[a]
MFRSR	1 Jan. – 31 Oct.	65.2[b]
MWR	1 Jan. – 31 Oct.	27.9
MPL	1 Jan. – 31 Oct.	64.2[c]
VCEIL	1 Jan. – 31 Oct.	117.6[d]

Notes:

a. The Skyrad, Grnrad, and Smet loggers each experienced periodic gaps between 1 and several hours as result of a problem with the data collection software configuration. This problem began in February and persisted until early May.

b. Most of the MFRSR gaps came during an extended period of down-time at the beginning of the year. The instrument was back on line during a RESET visit on 7 February 1998.

c. The MPL experience significant down-time because of problems with the laser diode supply. The supply was replaced during a RESET visit in May. Prior to that time, the MPL would operate for a few hours to a day, then would quit. There are many gaps during this period.

d. The Ceilometer has experienced numerous short gaps as well as several extended ones. The longest extended gap occurred during the period 21 February to 19 April. Other extended gaps include 5-8 January, 5-7 February, 25-30 May, and 11-15 June.

2. Note obvious data outliers: For each data stream, we are identifying some criteria that describe what constitutes reasonable data. We are going through all the data streams and noting where the data contradicts these guidelines.

3. Note more subtle data issues: Wherever possible, we are comparing similar data streams. For example:

- the NIP can be compared with the difference of the total and diffuse Eppley PSPs;
- the two up-looking PIRs (one shaded and one not) can be compared;
- the Net Radiometer on the GNDRAD stand can be compared with the net irradiance calculated from four broad band Eppley radiometers;
- the down-looking PIR can be compared with the down-looking IRT;
- the microwave radiometer can be compared with integrated water vapor; and
- the two anemometers on the meteorological tower can be compared.

Important issues observed during this period include continued poor response from the MFRSR, continued problems with the MWR heater, and water on the MPL telescope.

The MFRSR and MWR problems were reported previously. The MFRSR has six narrow band filtered channels. These filters are subject to drift, altering the calibration of their respective channels. This change in the calibration can be significant (a factor of ten or more) and can occur rapidly (over the course of a few weeks). Under conditions where clear skies occurred frequently, such a drift could be accounted for because Langley regressions of the top of atmosphere narrow band flux could be used to track the change. However, in the TWP, clear skies are rare. Thus it is difficult to obtain frequent enough Langley regressions to compensate for the filter drift.

The MWR heater that is meant to dry the Teflon window does not appear to be working. Without this heater, it takes up to about half a day for the window to dry. When there is water on the window, the MWR data cannot be used. During such periods, the retrieved vapor and liquid appear to decay with time constants of 10s of minutes to a few hours. This is a serious problem when the heater is not working during extended rainy periods.

Finally, we observed a degradation in the MPL sensitivity during two periods: 2– 11 August 1998 and 23 August – 16 September 1998. This problem has been linked to water observed on the MPL telescope. As a short term fix, a light has been set up to heat and dry the telescope. This seems to be working, but we need to determine where the water is coming from.

1.2.2 Manus Data Quality Projection

The TWP site science team is actively involved in an inter-site effort to improve and standardize QC analysis throughout ARM. We are working with individuals from the NSA and SGP site science teams as well as the ARM data system team on a variety of QC issues. At our office we are working most directly on the development of automated and manual flagging procedures. We have begun a pilot project with the short wave

instruments to show proof of concept. We have codes in hand that flag short wave data automatically - we now need to optimize these codes to provide the most useful information to the various users (the science team for data selection and mentors and site scientists for trouble shooting).

The manual part of the QC process is done with DQRs. Through many recent discussions, we are working to optimize the manual entry (and subsequent retrieval) of QC information. We hope to structure the manually entered metadata in such a way that it can be automatically merged with the automated flags to produce an overall picture of data quality. We also need to work with the programmers who are developing QC display tools to optimize how we display the QC information for users. All of this will take considerable work, but there are many people committed to working on the problem.

The biggest challenge in the next six months will be to adapt to checking the data for two sites. To do the quality testing for two sites efficiently and well, it will be increasingly important to automate as much of our testing as possible. Automating QC checks will likely be a large part of our development effort during the next six months.

2.0 NAURU SITE (ARCS-2), REPUBLIC OF NAURU

This second TWP site is located on Nauru Island in the central Pacific (Fig. 2). The Nauru site was chosen because of its location on the eastern edge of the warm pool under La Niña condition and its variable climate associated with ENSO events. Also its small size and isolation suggest that its climate should be strongly oceanic. The site is located in the Denigomodu District near the General Hospital on the west side of the island at 0.522 °S, 166.913 °E, 7m MSL (Fig. 5).

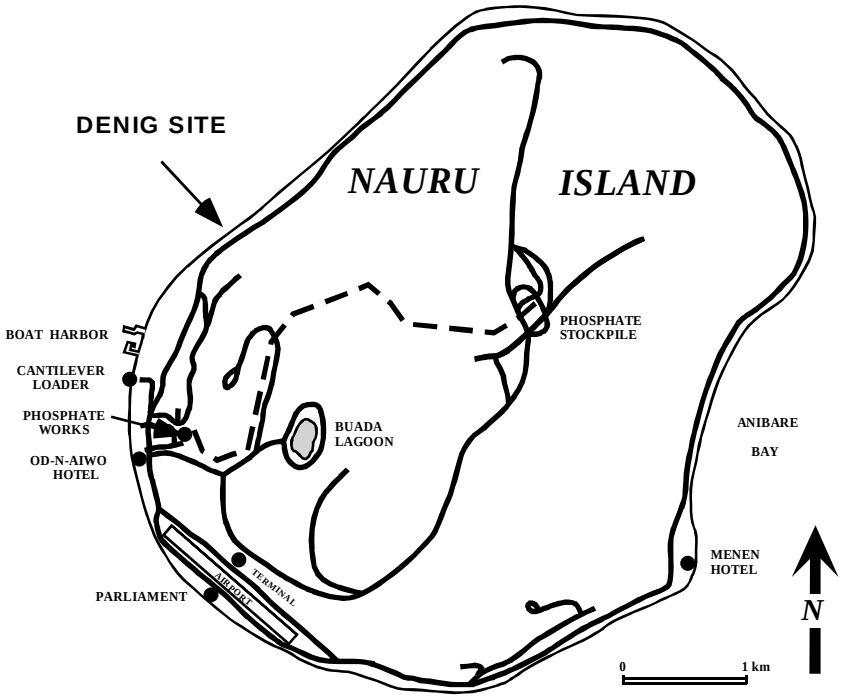


Fig. 5. Nauru Island. The ARM station is located in Denigomodu District on the western shore.

The ARCS-2 was installed at this location during October and November 1998. In addition to the standard set of ARCS instruments, the Nauru site has an Atmospheric Emitted Radiance Interferometer (AERI), a hydrogen generator to produce lift gas for the balloon soundings, and a remote balloon launcher. Figures 6 and 7 show panoramic views of the site.

Formal operations of the Nauru site began with the official opening ceremony on the island on 20 November 1998. The operations are a joint effort of the ARM Tropical Western Pacific (TWP) Program Office and the Nauru Department of Island Development and Industry (IDI).

Fig. 6. Panoramic view of site looking northeast to southeast (left to right).

Fig. 7. Panoramic view of site looking southeast to northwest (left to right).

2.1 Nauru Operations

Nauru IDI is in charge of the daily operations of the site. Assistance in performing these duties and in troubleshooting problems is provided by the TWP Operations Center in the US. Phone, fax, e-mails and satellite communications are made between the site and the Operations Center. A REgional SErvice Team (RESET) visits the site periodically to perform maintenance and calibration. These routine visits are nominally scheduled at six -month intervals. Additional visits are made when required. Appendix B shows the Nauru site layout of instruments and facilities.

2.1.1 Nauru Operations Status

The Nauru site has been operating since 21 November 1999. Currently all planned instrumentation are installed and operating. Hydrogen is being used as the lift gas for the once per day balloon borne sounding at 00Z (1200 local time). Health and status data are transmitted hourly from the site to the ARM Experiment Center via the GOES satellite system. All data are returned on tape monthly by courier service. Locally, three Nauru IDI personnel operate the site.

RESET Visits:

A Regional Service Team (RESET) visit consists of two or more TWP technicians and is classified as either routine or non-routine visits. Routine visits are primarily aimed at instrument calibration, observer training, and semi-annual maintenance. They are scheduled at 6-month intervals. Non-routine visits are for special retrofits or emergency repairs and can be initiated at any time.

During July through December 1998 TWPPO conducted no RESET trips to Nauru.

Significant Events:

Below are significant operational events that occurred during the July – December 1998 period. The sequential labels (INU-SE-N) indicate the Nauru (INU) Significant Event (SE) and number (N). A record of all events is available on the TWP website at: www.twppo.lanl.gov.

INU-SE-1: H2 Generator stops operating:
The H2 Generator had problems running continuously due to thermal control breakers shutting down the system almost every week. The H2 Generator operations were stopped on 29 December 1999 until a conclusive diagnosis and repair could be made. Parts were sent and a repair is scheduled for the RESET-5 in 1999. Balloons were launched using helium for 2 weeks after the H2 Generator shutdown until we exhausted the Helium supply.

2.1.2 Nauru Operations Projection

During the January – June 1998 period there will be one scheduled RESET visit to Nauru:

RESET-5N Visit (combined with RESET-5M) This is a routine visit for the following:

- **H2 Generator:** Coordinate H2 Generator repair.
- **Diesel Generator:** Safety mods to the generator and fuel tank.
- **ADaM/EVE:** Tape backup and sync up ADaM & EVE.

2.2 Nauru Data Quality

2.2.1 Nauru Data Quality Status

We have just received the first six weeks of data from Nauru. Quick looks of these data indicate no significant gaps and no obvious problems, however, we have not done a rigorous data inspection.

2.2.2 Nauru Data Quality Projection

We will apply the same analysis tools that we've been using for Manus as well as new automated ones. We should be able to release at least the first four months of Nauru data in the next six-month period.

3.0 SITE 3

We would like to locate the third ARCS in a region normally well out of the warm pool. A possible candidate for the third site is Kiritimati Island (1.87^{o}N, 157.33^{o}W; Fig. 2). Discussions have begun with the Kiribati government concerning this possibility. We would like to begin operations of the third site in 2000.

The South Pacific Regional Environment Programme (SPREP) will assist us with government agreements, contract negotiations, and staffing of the sites. SPREP will also assist with contract oversight on an as-needed basis.

The overall plan for the third site has four elements:

- Determination of the site location
- Establishing site contracts and agreements
- Preparation of the site for installation, including all physical construction and utilities, setting up communications and data transfer, and hiring and training staff.
- Installation of the site.

4.0 IOPs, CAMPAIGNS, AND OTHER COLLABORTIONS

IOP Nauru 99 is a campaign offshore of Nauru Island planned for the June – July 1999. The Nauru Science and Implementation Plan can be found at www.etl.noaa.gov/nauru99 under Expeditions.

The ARCS stations supply measurements of the surface radiation budget and radiatively important atmospheric properties at single points. Understanding how island measurements represent conditions over the nearby ocean is important for the interpretation of the measurements. The ARM program is making a concerted effort to address this question. This requires making similar measurements on the open ocean near the islands. Also, there are a variety of atmospheric processes, such as the vertical transport of water and energy by tropical convection that cannot be addressed within normal operating conditions in the TWP due to logistical and cost constraints.

Nauru99 was conceived to address several hypotheses:

- Island effects are minimal during periods of active convection such as the Madden-Julian Oscillation (MJO) effects and during the night.
- There may be some island affect during the day.
- Small islands do not affect isolated cirrus clouds.
- Island effects will be noticeable in cloud fraction and liquid water content, but the impact of small islands on overall downwelling radiation, relative to the open ocean, is small.

The Nauru99 operation will begin 18 June 1999, with the arrival of the Japanese ship MIRAI in the Nauru area. The NOAA ship RON BROWN will arrive a few days later; these two research vessels will occupy stations in two different triangle patterns designed to study different mesoscale processes. In the large triangle pattern, each ship will take position near NOAA TAO buoys at 165W longitude, equator and 2S latitude, forming a triangle with sides of approximately 200 km with the ARCS site, The small triangle will have sides of 25 km and 50 km. At some point, 1 or 2 concentrated platform intercomparisons will be made near the island. The operation will end when the RON BROWN departs on 18 July 1999 All dates are approximate at this time.

Both ships will have nearly redundant instrumentation to that on the island, including Lidars, S-band radar, radiosondes, and radiometers. Each ship will be operating 5-cm Doppler weather radar and dual-Doppler studies of clouds are expected. Each ship will be fully equipped to make direct measurements of all components of the air-sea energy flux, both by direct eddy-correlation and by bulk transfer methods. The RON BROWN will collect aerosols, which will be analyzed on board.

Research aircraft will be deployed throughout the operation to provide coverage between the vertices of the triangles. The Australian Bureau of Meteorology will deploy a fleet of aerosondes. Sets of aerosondes will be flown in various combinations along

the legs of the triangles. A Cessna research aircraft from Flinders University, Adelaide, Australia will concentrate on covering the boundary layer structure along the legs and in the center of the triangles.

The ARM site on Nauru will conduct rawinsonde launches on a schedule matching that of the ships. Some additional instrumentation at the site and at a couple of auxiliary sites on the island will complement the standard ARCS measurements. The exact configurations of these additions are being determined.

5.0 OCEAN PROJECT

The goal of the ARM TWP Ocean Project is to provide a means by which ARM can obtain data that apply to the oceanic environment and supplement the measurements taken at the TWP island stations. The ARM Ocean Working Group (AWOG) was formulated to create a means of focusing the ARM ocean activities. The primary scientific issues suggested by this group are:

- spatial variability of radiation and all fluxes in the oceanic heat budget;
- lower atmospheric mixed-layer physics;
- upper-ocean mixed-layer physics;
- island-induced errors;
- spatial and temporal variability in the sea-surface temperature (SST); and
- cycles of convection on all spatial scales.

In keeping with the ARM Science Plan for the TWP, both intensive field campaigns and long-term measurements of properties and fluxes at the ocean-atmosphere interface will be considered. As these activities require access to floating platforms, both ship and buoy observation systems are under development.

More information on the Ocean Project can be found at www.armocean.bnl.gov.

TAO Buoy Radiometer Program

ARM is participating in the international Tropical Atmosphere and Ocean (TAO) buoy program in the Pacific Ocean. With ARM support, the NOAA Pacific Marine Environmental Laboratory (PMEL) has developed a special digital version of the Eppley PSP for use with their next generation ATLAS buoy package.

Four prototype TAO-PSP radiometers have been operating successfully since June 1997. The daily average insolation values, transmitted via the ARGOS satellite, are most encouraging and it appears the internally stored, 2-minute averages will produce a good test of short-wave irradiance measurements. The program then deployed radiometers and rain rate sensors on all seven buoys along the 165E longitude line from 8N to 8S and all were measuring short wave radiation and rainfall in January 1998.

JAMSTEC is in the process of deploying their TRITON buoys at sites west of 165E. These buoys, which will eventually replace the NOAA buoys, will also have high quality radiation sensors, the Woods Hole IMET sensors. The TRITON buoys will completely replace all NOAA buoys west of 165E* in the next few years and it is essential that ARM establish connections to this data set to provide a good inter- comparison and added coverage in the TWP.

Instrumentation Development

Several instruments, under development for Volunteer Ship Observing System (VSOS) activities worldwide, are being considered for ARM/TWP observing platforms. A Fast-Rotating Shadowband Radiometer has been developed at BNL and was operated successfully on the CSP and TOCS cruises. A multi-frequency version was developed and deployed on two cruises in 1998. A marine version of the AERI, called M-AERI, has been developed by the University of Wisconsin and is operated by the University of Miami on several ships. A simple infrared thermometer has been used to successfully measure SST to the required +/-0.01 C accuracy. Engineers at BNL are working with scientists at Univ. of Colorado to develop this into a low-cost, unmanned system for the VOS effort. A series of field inter-comparison studies are planned with the goal of achieving an optimum measurement system for the volunteer ship network worldwide.

6.0 EDUCATIONAL OUTREACH

Plan Overview

DOE mandates that its programs have some form of educational outreach program. From the first days of ARM, developing the education outreach program has been assigned to each CART site. A small but consistent funding base has been allocated for the development of the education program, and the Site Scientist and/or the Site Program Manager usually administer it. The content of the site education program, while at the discretion of each site, must be relevant to the communities around each CART site.

The TWP presented us with unique problems for developing an education plan. The three TWP sites are spread out over a huge geographic area, and each site is in a different country with a unique language and culture. More importantly, the local schools generally lack advanced technology, such as Internet capabilities. Many do not have TV, video, or film resources and some are lacking the material, infrastructure and educational resources that are considered to be standard in the US. Our goal has been to identify the various educational needs in the communities close to each site, and to attempt to deliver enrichment opportunities to satisfy some of those needs.

The overall vision for the TWP education outreach plan is to enrich primary, secondary and college science programs in the TWP region with a focus on basic science, climate, climate change and effects relevant to the region. The TWP educational outreach plan

must have a broad scope to address local, national and regional issues and needs, and be flexible to stay current and relevant over the potential 10-year operating period of the TWP locale. The program must include both technical training for on-site staff, and public education and outreach for local communities, as well as addressing the needs of the more formal education systems of communities.

Significant Events

In November 1998 we held the first Curriculum Implementation Workshop for teachers and educators on Nauru. We were assisted by one of the curriculum authors, Dr. Than Aung, from the National Tidal Facility at Flinders University, Australia. Thirty-five teachers and principals from two high schools and several primary schools attended the 5-day workshop and earned certificates of completion. Teachers learned how to present about 50% of the activities in the curriculum modules. A survey at the end of the workshop showed that the response was overwhelmingly positive, and that the workshop served the needs of the local schools.

Plan Goals

- **Needs Assessment**: Meet with local and regional educators to determine the ways we can support educational needs for communities and the region. Needs assessment must be an ongoing task.

- **Curriculum Development**: Develop a regional curriculum for enriching science curricula in the secondary schools in collaboration with SPREP and other organizations.

- **Curriculum Implementation**: Develop and implement workshops to assist education departments using the curriculum. We will focus first on the communities and education departments close to the TWP sites, but will also participate in regional implementation efforts**.**

- **SPaRCE (Schools of the Pacific Rainfall Climate Experiment)**: Support the SPaRCE program through assisting in the enrollment of schools in the program, support for development of automated school weather stations and advanced equipment, and also in participation in and joint sponsorship of in-service training.

- **Newsletters**: Develop quarterly newsletters for schools and for public information. These newsletters will have information on ARM and TWP progress, information on climate issues with a regional focus (e.g. El Niño) as well as a Q&A section for readers to submit issues and concerns.

- **Material Support**: Support the improvement of material and equipment as needed and as funds available in the schools close to the ARCS sites. This material support

may include books, video resources, computer usage, and simple automated weather stations and equipment.

- **Teacher Training**: Support enrichment for teachers as needed and as funds are available including attendance at meetings, and other in-service training.

- **ARM Resources**: Support tours of the ARCS, access to TWP and ARM data, and help with data analysis. TWP scientists and technicians will visit schools and give presentations to faculty and classes on the ARM program; we will assist on occasion with local needs for computer support or equipment issues.

- **Public Relations**: Develop a public relations plan in conjunction with on-site colleagues in the relevant government departments. Activities may include town meetings, local events, site tours, radio or TV interviews. The TWP program goal is to be responsible and communicative about ARM activities, and to assist with building local capacity for addressing climate and other environmental issues.

- **Technical Training**: Develop a technical training plan in conjunction with the on-site staff, the staff supervisors or employers, and the TWP program office. Build on existing technical skills, and offer opportunities for training that might not normally be available to the technical and management staff assisting with the day-to-day operations of the ARCS. Initially, observers will be trained to operate the equipment at the site. The initial equipment training will be followed by side-by-side working and training with TWP technicians, engineers and scientists; it could include formal training given by another provider depending on funding.

Plan Implementation Summary: July 1998-June 1999

(Plan elements completed prior to July 1998 are listed in the previous Site Science Mission Plan, July-December 1998.)

Plan Element	Progress: July-Dec 98	Planned: Jan-June 99
Needs Assessment	• Meetings with educators in Nauru: 98.	• Continue discussion with Manus and Nauru education departments. • Initiate discussion with educators at the third TWP site after site selection.
Curriculum Development	• Curriculum published 1998 by SPREP.	• Complete
Curriculum Implementation	• Curriculum workshop in Nauru, November 1998.	• Draft and complete NTF (Flinders Univ.) contract for workshop. • Complete curriculum implementation plan for 1999-2000; begin implementation. • 1999 Port Moresby and Manus workshops planned for May 99.
SPaRCE (Schools Of The Pacific Rainfall Climate Experiment	• Support SPaRCE program with small funding grant from 1994 to present. • Reinstated contract with scope of work for 2 years.	• SPaRCE participation in curriculum implementation workshops planned for 3rd quarter FY99.
Newsletters	• Drafted design 10/30/98. • Completed design 10/30/98. • Drafted Issue #1 12/15/98.	• Issue #1 distribution 2/28/99. • Issue #2 drafted 1/30/99; • Issues to be shipped for distribution at each location quarterly (15 Jan, 15 Apr, 15 Jul, and 15 Oct).
Material Support	• Book shipment (donated books from the TWP team) to Manus 9/15/98.	
Teacher Training		• See implementation workshops.
ARM Resources	• TWP installation team visited schools and presented ARM program to faculty and classes during Nauru installation in Oct/Nov 98.	• Continue TWP site tours. • Train Nauru Observers to conduct site tours.
Public Relations	• Finalized PR plans for Manus and Nauru 11/30/98. • Conducted TV/radio interviews in Nauru during installation. • Attended local meeting for PICCAP (Pacific Island Countries Climate Assistance Program in Nauru July 98. • Compiled and distributed Nauru PR packages July 98.	• Send PR packages to PNG NWS Head Office by 3/15/99. • Complete Nauru 99 Fact Sheet; distribute in Nauru April 99.
Technical Training	• Computer training for all Manus Observers completed 12/15/98. • Continued technical training for NWS technical staff at Manus completed Aug 98. • Nauru On-site Observers technical training completed during installation Oct/Nov 98.	• Management training for Officer in Charge, Manus on hold pending PNG NWS restructure. • Plan WMO training for Nauru Observer #2. • Overall review and revision of Manus and Nauru staff training plans: 1 April - 30Sept 1999.

7.0 DISTRIBUTION OF DATA

During July – December 1998, we released the following data sets:

Manus:

December	1997
January	1998
February	1998
March	1998
April	1998
May	1998
June	1998
July	1998

Specific information on data availability by instrument and day can be found at: www.dmf.arm.gov.

Available data can be obtained from the ARM Experiment Center by contacting

ARM Experiment Center Manager, Ms. Robin Perez
robin.perez@arm.gov

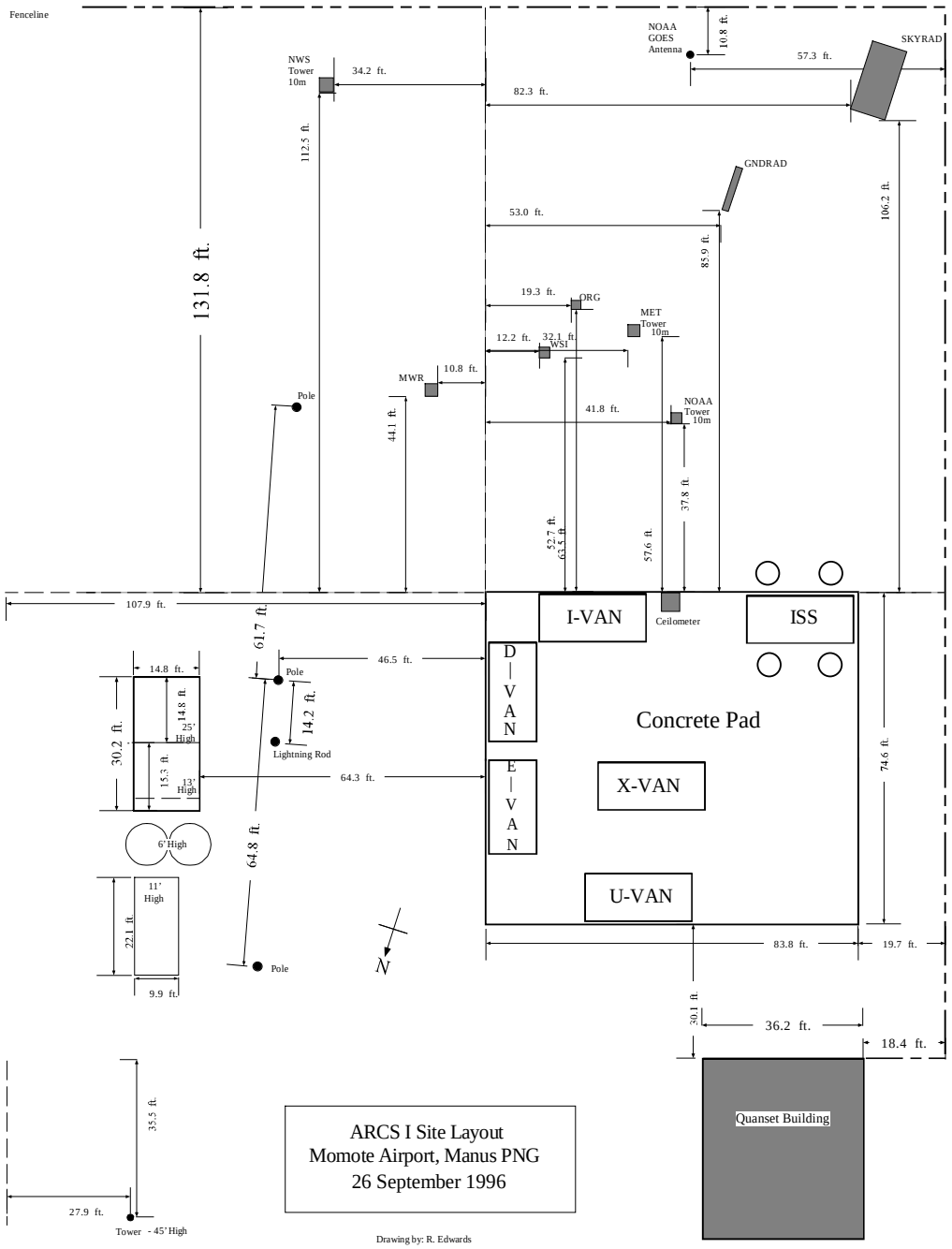
ACRONYMS

ACCESS	Automated Communication Control and Environmental Supervision System
ADaM	ARCS Data and Management System
ARCS	Atmospheric Radiation and Cloud Station
ARM	Atmospheric Radiation Measurement
ATLAS	Atmospheric Laboratory for Applications and Science
AVHRR	Advanced Very High Resolution Radiometer
AWOG	ARM Ocean Working Group
BBSS	Balloon Borne Sounding System
BNL	Brookhaven National Laboratory
CLASS	Cross-Chain LORAN Atmospheric Sounding System
CSP	Combined Sensor Program
DOE	U.S. Department of Energy
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Nino Southern Oscillation
GNDRAD	Groundward Looking Radiometer Stand
GOES	Geostationary Operational Environmental Satellite
HRPT	High Resolution Picture Transmission
IOP	Intensive Operational Period
IRT	Infrared Radiometer
ISS	Integrated Sounding System
JAMSTEC	Japanese Marine Science and Technology Center
MAS	Manus
MFRSR	Multi-Filter Rotating Shadowband Radiometer
MPL	Micro-Pulse Lidar
MWR	Microwave Radiometer
N	Number
NCAR	National Center for Atmospheric Research
NIP	Normal Incidence Pyreheliometer
NOAA	National Oceanic and Atmospheric Administration
NSA/AAO	North Slope of Alaska and Adjacent Arctic Ocean
NTS	National Tidal Facility
NWS	National Weather Service
PIR	Precision Infrared Radiometer
PMEL	Pacific Marine Environmental Laboratory
PNG	Papua New Guinea
PSP	Precision Spectral Radiometer
RACE	Remote Accessibility Communication Equipment (ACCESS)
RASS	Radio-Acoustic Sounding System
RESET	REgional SErvice Team
SAM	Supervision and Management (ACCESS system)
SE	Significant Event
SGP	Southern Great Plains
SKYRAD	Skyward Looking Radiometer Stand

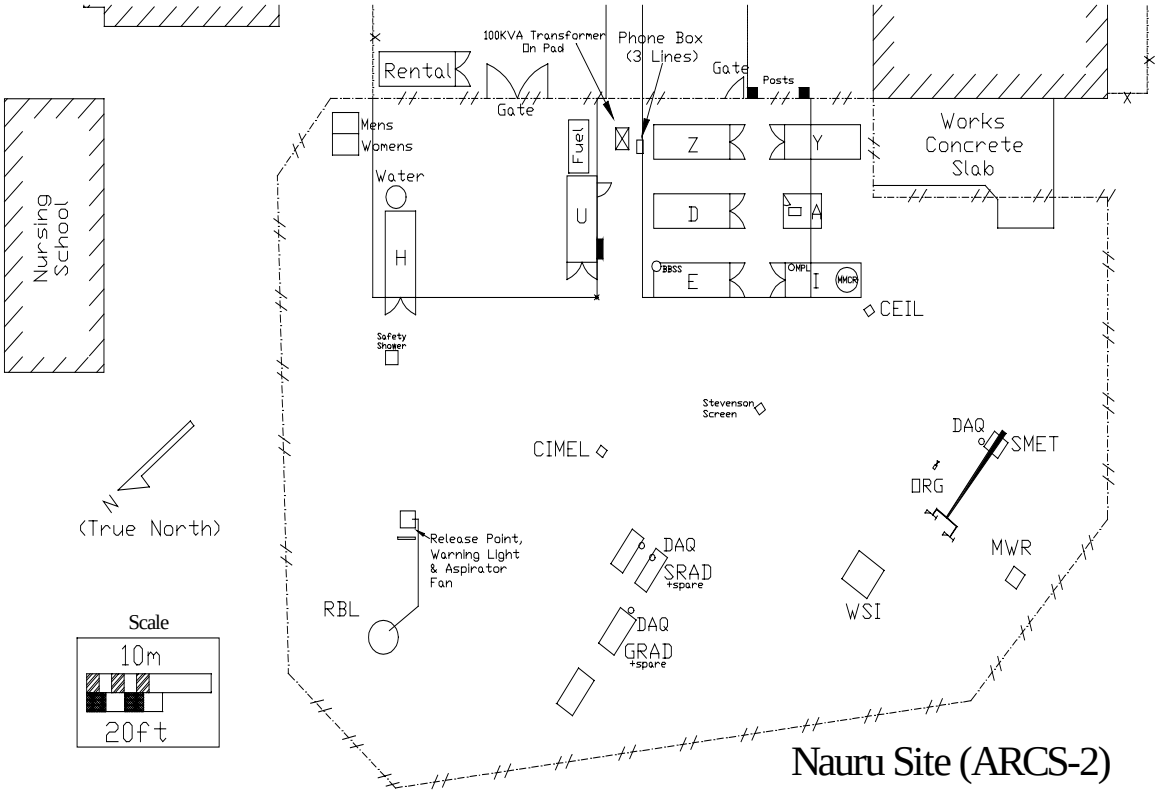
SPaRCE	Schools of the Pacific Rainfall Climate Experiment
SPREP	South Pacific Regional Environment Program
SST	Sea-Surface Temperature
TAO	Tropical Atmosphere-Ocean
TOCS	Tropical Ocean Climate Study
TOGA	Tropical Ocean and Global Atmosphere
TOGA COARE	Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment
TRITON	Triangle Trans-Ocean Buoy Network
TWP	Tropical Western Pacific
VCEIL	Vaisala Ceilometer
VISSR	Visible and IR Spin Scan Radiometer
VOS	Volunteer Observing Ship
VSOS	Volunteer Ship Observing System
WMO	World Meteorological Organization

APPENDICES

A. Manus Site Layout



B. Nauru Site Layout



Nauru Site (ARCS-2)